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# Hawaii Agricultural Experiment Station
HONOLULU

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# Comparative Value of Legumes as Green Manures.

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## INTRODUCTION.

For many years, the Hawaii Agricultural Experiment Station has advised the growing of leguminous crops as green manures in every system of permanent agriculture under Hawaiian conditions. The value of green manures for practically every type of soil is well known, and for the heavy clay soils of Hawaii, with their tendency to puddle, humus is especially needed. The organic material supplied by plowing under leguminous crops lightens the soil, improves the drainage, and by its decay makes the phosphoric acid and potash in the soil more available to following crops. The chief value of legumes is, however, in the nitrogen which they add to the soil. As is well known,

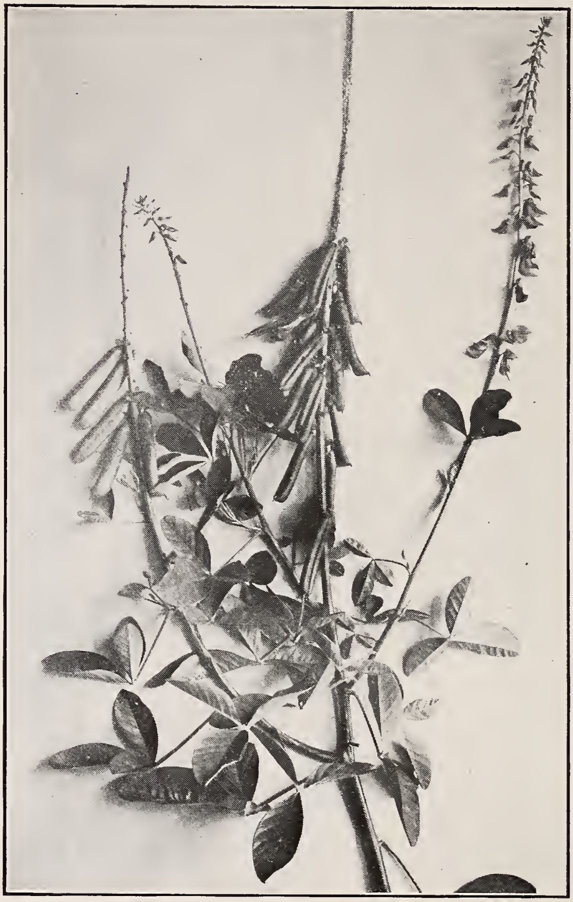

Fig. 1. *Crotalaria saltiana*, one of the wild "rattlepods" recommended as a green manure. The canoe-shaped pods are light yellowish brown in color and contain yellow seeds.

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they differ from most other plants in that the bacteria, which live on their roots and form nodules resembling small warts, are able to take up nitrogen from the air and change it into a form which the plants can use. When the legumes are plowed under, the nitrogen they contain is added to the soil, increasing the supply upon which the succeeding crops can draw.

## NITROGEN CONTENT OF LEGUME VARIETIES.

In experiments conducted by the chemical department of this station, 32 varieties of legumes were grown on two soils of different types. One soil was a dark brown clay from the station grounds, the other, an acid red clay from the Kunia district of the Island of Oahu. Three crops were grown of each of the 32 varieties of legumes, using 4 pots for each trial of each variety. At maturity, the plants were removed, weighed, and analyzed for nitrogen. Analyses of the soil for nitrogen were made before planting and after removing the crop. These analyses indicate that a large portion, at least, of the nitrogen in the legumes was obtained from the air through the associated root-tubercle bacteria.

The results of these experiments will be given in detail in a forthcoming publication by Alice R. Thompson, Assistant Chemist of this station, but as the projected bulletin is technical in character, it is thought that some of the data, presented in a less technical form, will be of popular interest and value. The yield of freshly cut stems and leaves (or green forage) appeared to be the most practical basis on which to estimate the nitrogen content of the different leguminous crops. The yields on this basis can be ascertained with little trouble by mowing and weighing the crop from a small measured area.

The approximate nitrogen content of the various legume varieties, calculated on the above basis, is given in Table I. Six varieties of cowpeas were grown, including the Whippoorwill, Taylor, Redripper, Brabham, Black, and mixed, but the results for these different varieties agreed so closely that they were averaged. The results for the four velvet beans grown, including the Mauritius, Florida, Lyon, and Brazilian, also agreed very closely and were averaged.

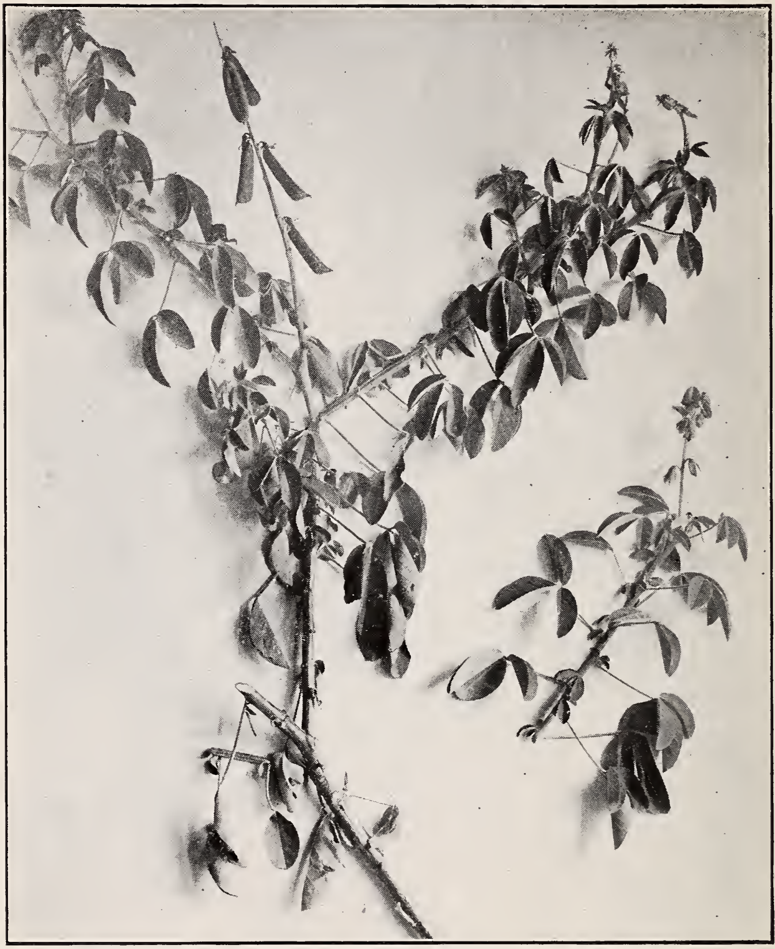

Fig. 2. *Crotalaria incana*, one of the wild "rattlepods" recommended as a green manure. This rattlepod is distinguished from the similar one shown in Fig. 1 by the fine hairs on the stems, leaves, and pods. The pods are black in color with dark or greenish seeds.

TABLE I. *APPROXIMATE NITROGEN CONTENT OF LEGUME VARIETIES.*

(Calculated on the basis of a ton of fresh cut stems and leaves).

| VARIETY | Nitrogen in total plant lbs. | Nitrogen in stems and leaves lbs. | Nitrogen in roots lbs. |
|---|---|---|---|
| Sunn hemp (*Crotalaria juncea*) | 20.2 | 16.0 | 4.2 |
| Indigo plant (*Indigofera anil*) | 28.4 | 20.4 | 8.0 |
| Rattlepod (*Crotalaria saltiana*) | 23.5 | 15.3 | 8.2 |
| Rattlepod (*Crotalaria incana*) | 18.9 | 15.9 | 3.0 |
| Oregon vetch | 20.0 | 12.3 | 7.7 |
| Jack bean (*Canavali ensiformis*) | 16.3 | 15.0 | 1.3 |
| Velvet beans | 14.0 | 11.7 | 2.3 |
| Otootan soy bean | 20.0 | 15.7 | 4.3 |
| Partridge pea (*Cassia chamaecrista*) | 23.7 | 19.6 | 4.1 |
| Cowpeas | 12.1 | 10.6 | 1.5 |
| Hairy vetch | 13.3 | 9.4 | 3.9 |
| Florida beggar weed (*Desmodium tortuosum*) | 19.0 | 15.6 | 3.4 |
| Barchet soy bean | 21.2 | 15.6 | 5.6 |
| Spanish clover (*Desmodium uncinatum*) | 19.8 | 12.8 | 7.0 |
| *Sesbania aegyptiaca* | 11.4 | 7.1 | 4.3 |
| German lupine | 8.7 | 7.1 | 1.6 |
| *Phaseolus semierectus* | 17.3 | 13.6 | 3.7 |
| Mung bean (*Phaseolus mungo*) | 15.5 | 13.8 | 1.7 |
| Kulthi (*Dolichos biflorus*) | 12.5 | 11.6 | 0.9 |
| Sensitive plant (*Mimosa pudica*) | 13.7 | 6.8 | 6.9 |

Table I gives the name of the variety of legume and the amount of nitrogen in the stems and leaves, in the roots, and in the total plant, calculated on a basis of a ton of fresh cut stems and leaves. That is, if a crop of legumes is cut and weighed while fresh, then in each ton of the weighed stems and leaves and in the roots belonging to that ton, there will be approximately the amount of nitrogen shown in the table. If a grower, for example, wishes to know how much nitrogen a crop of sunn hemp will add to his soil when turned under, he can go to his field and cut a known area, as one-tenth of an acre, and weigh the stems and leaves cut. If they weigh say, 1.8 tons, then in the stems and leaves cut there will be 16 pounds of nitrogen per ton, and in the roots left in the ground, 4.2 pounds, making a total of 20.2 pounds of nitrogen per ton, or 36.4

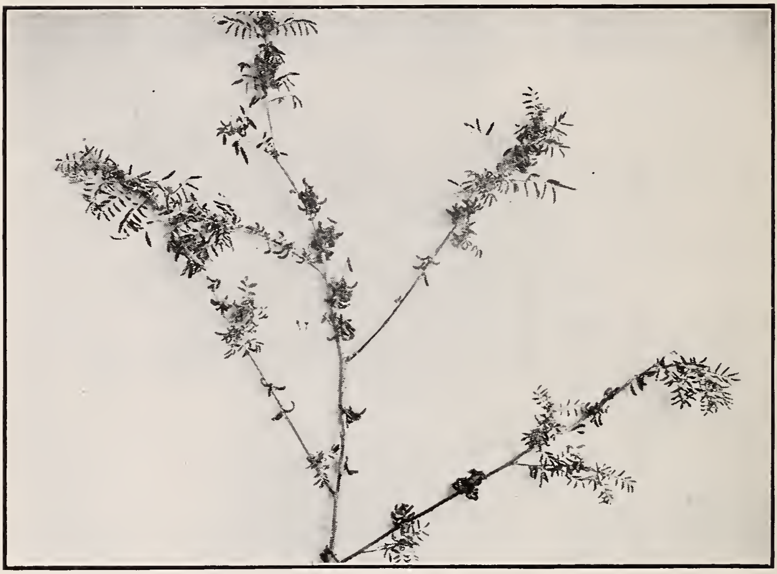

Fig. 3. Indigo plant (*Indigofera anil*), a leguminous weed very high in nitrogen. Easily identified by the clusters of tiny black pods resembling miniature bunches of bananas.

pounds for the 1.8 tons. For the whole acre, there would be ten times this amount or 364 pounds of nitrogen.

It is to be understood of coure, that the figures in Table I are only approximate. They are the average of a large number of pot experiments which do not exactly duplicate field conditions.

The amount of nitrogen in a given legume is not absolutely constant but varies to some extent with different conditions of soil and climate. However, the figures given are sufficiently representative for ordinary calculations, and as they are based on crops grown under similar conditions, they should be of considerable value in comparing the different legume varieties. Although the crops grown on poor soil were smaller than those on good soil, the amounts of nitrogen calculated on the basis of a ton of fresh cut stems and leaves were found to agree fairly closely for both soils.

## YIELDS AND TIME REQUIRED FOR MATURING DIFFERENT LEGUMES.

In order to compare the amounts of nitrogen added to the soil by different legumes, the yields of the different legumes and also the time necessary to mature a crop for green-manuring must be considered.

Data on yields and growing time are given in Table II, in which comparisons are also made of the nitrogen-adding value of the different legumes.

TABLE 2. *COMPARATIVE NITROGEN ADDING VALUES OF VARIOUS LEGUMES GROWN AS GREEN MANURES.*

| VARIETY | Estimated tonnage of fresh cut stems and leaves per acre | | Approximate nitrogen content of total plant per ton of fresh cut stems and leaves. | Estimated nitrogen added to soil per acre by an average crop turned under. | Estimated time necessary to mature crop for green manure. |
|---|---|---|---|---|---|
| | Range | Average | | | |
| | TONS | TONS | POUNDS | POUNDS | MONTHS |
| Sunn hemp (*Crotalaria juncea*) | 10 to 26 | 18 | 20.2 | 364 | 3 |
| Indigo plant (*Indigofera anil*) | 8 to 16 | 12 | 28.4 | 341 | 6 |
| Rattlepod (*Crotalaria saltiana*) | 8 to 20 | 14 | 23.5 | 329 | 3 |
| Rattlepod (*Crotalaria incana*) | 10 to 24 | 17 | 18.9 | 321 | 3 |
| Oregon vetch | 9 to 19 | 14 | 20.0 | 280 | 5 |
| Jack bean (*Canavali ensiformis*) | 12 to 20 | 16 | 16.3 | 261 | 5 |
| Velvet beans | 12 to 24 | 18 | 14.0 | 252 | 4.5 |
| Otootan soy bean | 6 to 16 | 11 | 20.0 | 220 | 4 |
| Partridge pea (*Cassia chamaecrista*) | 5 to 12 | 8.5 | 23.7 | 201 | 3.5 |
| Cowpeas | 10 to 20 | 15 | 12.1 | 182 | 3 |
| Hairy vetch | 8 to 18 | 13 | 13.3 | 173 | 6 |
| Florida beggar weed (*Desmodium tortuosum*) | 6 to 12 | 9 | 19.0 | 171 | 6 |
| Barchet soy bean | 6 to 10 | 8 | 21.2 | 170 | 4 |
| Spanish clover (*Desmodium uncinatum*) | 5 to 10 | 7.5 | 19.8 | 149 | 3.5 |
| *Sesbania aegyptiaca* | 10 to 14 | 12 | 11.4 | 137 | 4 |
| German lupine | 12 to 18 | 15 | 8.7 | 131 | 3.5 |
| *Phaseolus semierectus* | 5 to 8 | 6.5 | 17.3 | 112 | 3 |
| Mung bean (*Phaseolus mungo*) | 4 to 10 | 7 | 15.5 | 109 | 3 |
| Kulthi (*Dolichos biflorus*) | 6 to 10 | 8 | 12.5 | 100 | 4.5 |
| Sensitive plant (*Mimosa pudica*) | 2 to 4 | 3 | 13.7 | 41 | 6 |

Table II gives the kind of legume, the range in yield and average tonnage of fresh cut stems and leaves per acre, data obtained from numerous field trials by the agronomy department; and the amount of nitrogen in the total plant per ton of fresh cut stems and leaves, as given in Table I. In addition Table II shows the estimated amount of nitrogen added per acre by turning under the average crop of each legume. These figures are obtained by multiplying the average tonnage of fresh cut stems and leaves per acre by the pounds of nitrogen in the total plant. While crop yields are affected by the rainfall, the season, the soil, etc., still these figures, based on an average crop production,

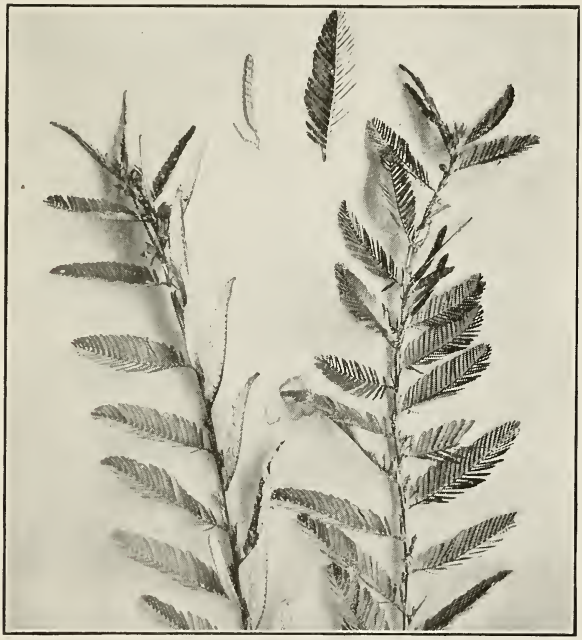

Fig. 4. Partridge Pea or Japanese tea. (*Cassia chamaecrista*), a leguminous weed high in nitrogen. Easily recognized by its yellow flower and its similarity to the sensitive plant.

should be of considerable value in comparing the nitrogen adding efficiency of the different legumes and in indicating desirable varieties.

The estimated time required to mature a crop for a green manure also appears in Table II. These figures should be taken into consideration where time is an important factor or several leguminous crops are to be grown in succession.

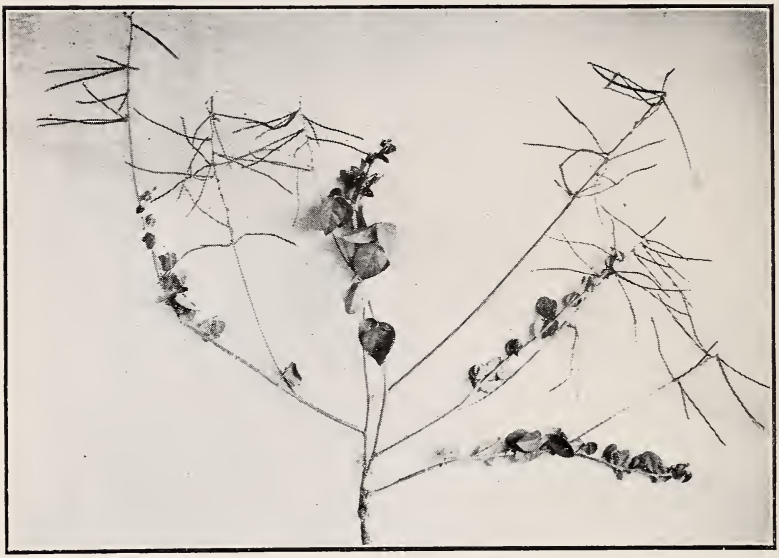

Fig. 5. *Phaseolus semi-erectus.* When thickly sown on worn out pasture land, this legume has been found of considerable value as a green manure.

## DESCRIPTION OF VARIETIES.

Nearly all the cultivated legumes mentioned in the above tables are well known. These legumes have been described in a previous publication of the station.[1]

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[1] Hawaii Sta. Bul. 23 (1911).

Seven of the legumes given in the tables occur commonly as weeds in Hawaii. Of these the most important appear to be the wild "rattlepods" (*Crotalaria saltiana* and *Crotalaria incana.*) These rattlepods grow wild and seem adapted to nearly every kind of soil and climate occurring in Hawaii. An abundant supply of seed can be easily obtained by gathering the pods from the wild plants and allowing them to dry on a large cloth in the sun. The seeds which are expelled from the pods on drying are easily separated for planting.

Some of the advantages of the *Crotalaria saltiana* have been mentioned in a previous publication of this station.[1] Because of the high nitrogen content of the wild rattlepods as shown in the tables, and their adaptability to soil and climatic conditions suitable for the cultivation of pineapples, they are recommended as a green manure for the preparation of pineapple fields. These rattlepods are also especially valuable as a green manure for the manganese soils of Oahu, as they are about the only legumes apparently uninjured by the black manganiferous soils.

The chief objection to these wild rattlepods is the woody character of their stems which causes some difficulty in turning them under. This woody character appears to the writers, however, as of considerable advantage in other ways under Hawaiian conditions. Under mainland conditions, with the short period from planting to harvest of the main crop, a lush, rapidly decaying and humifying green manure such as the cowpea is desirable. Under the semitropical Hawaiian conditions, rapid decay is undesirable as the humus is soon "burnt out" of the soil. With a crop such as pineapples, requiring a long growing period, the slower decay resulting from the more woody character of the stems, would appear to constitute a recommendation for these wild rattlepods as green manures.

Other legumes given in the tables which occur commonly as weeds are the indigo plant, (*Indigofera anil,*) partridge

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[1] Hawaii Sta. Rpt. (1914), p. 21.

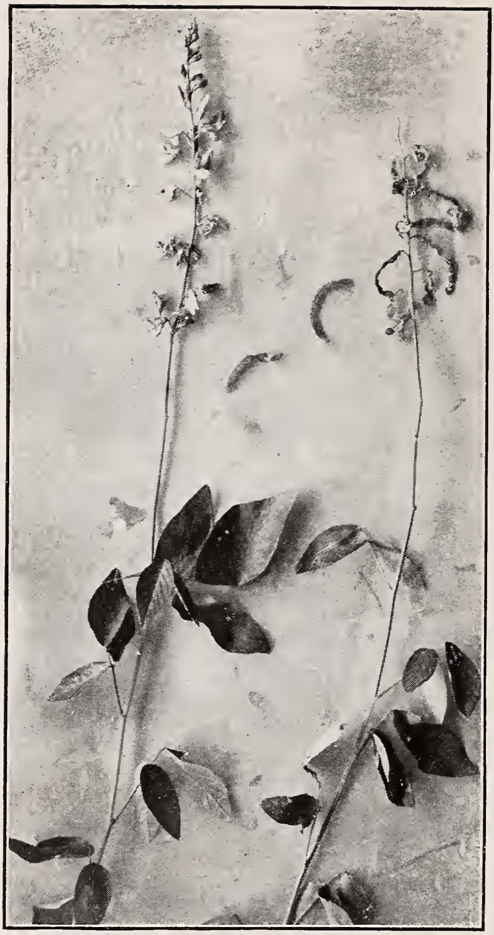

Fig. 6. Spanish Clover (*Desmodium uncinatum*). A thorough disking is sufficient preparation for planting this legume.

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pea (*Cassia chamaecrista*), *Phaseolus semierectus*, and Spanish clover (*Desmodium uncinatum*), illustrated in figures 3, 4, 5, and 6, respectively. Because of its well known appearance and non-importance as a green manure, the sensitive plant is not given. Under certain conditions it may be advisable to grow some of these other leguminous weeds as a green manure, especially the *Indigofera* and the *Cassia* which have a very high nitrogen content. The principal object in including these weeds in the tables, however, is to show the store of nitrogen they contain, and to indicate that, in preparing new land, these leguminous weeds should be plowed under to add their nitrogen to the soil instead of being burned off, as is the usual practice.

## VALUE OF NITROGEN ADDED TO SOIL BY GREEN MANURE.

From the estimated amount of nitrogen added per acre by turning under the average crop of each legume, it is very easy to estimate the value of the nitrogen added to the soil. Twenty cents per pound is a low figure for organic nitrogen in commercial fertilizers, and the value of the nitrogen added by an average crop of sunn hemp (364 pounds) or of cowpeas (182 pounds) is apparent. Experiments at the Illinois Agricultural Experiment Station [1] with typical legumes show that about 45 per cent of the nitrogen in the tops of legumes is in water-soluble form and as such could be easily changed into a form available for following crops. Experiments conducted at this station show that the ammonification and nitrification (the changes which render the nitrogen available for following crops) of the nitrogen in cowpeas, turned under in the soil, compare very favorably with the ammonification and nitrification of dried blood under similar conditions.

## SUMMARY.

1. A table is given showing for a large number of legumes the approximate amount of nitrogen in the roots, in the stems, and leaves and in the total plant. From this table. each individual farmer can calculate, by determining the crop yield on a small portion of his field, the approxi-

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[1] A. L. Whiting, Illinois Sta. Bul. 179 (1915), p. 540.

mate amount of nitrogen that a leguminous crop will add to his soil when plowed under.

2. A second table shows the range in yields, and average crop yields for various legume varieties on soils of ordinary fertility, together with the approximate amount of nitrogen that an average crop of each legume variety will add to the soil if plowed under.

3. The sunn hemp and the wild "rattlepods" appear to be among the legumes possessing the highest nitrogen adding efficiencies and are therefore recommended as green manures in Hawaii.

## ACKNOWLEDGEMENT.

Thanks are hereby extended to Mr. J. E. Higgins, Horticulturist, for assistance in preparing the illustrations for this bulletin.